U.S. Air Force
Human Systems Center,
Environmental Planning Directorate
Brooks AFB, TX

FINAL REPORT

Requirements Analysis
for
Noise

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POC: U.S. Air Force
Human Systems Center,
Environmental Planning Directorate
Brooks AFB, TX

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EXECUTIVE SUMMARY

OBJECTIVE

The objective of this Requirements Analysis (RA) is to provide to Air Force Major Commands (MAJCOMs) information that can be used to identify solutions to technology needs related to developing noise models and reducing noise generated by aircraft and space launch vehicles and the associated impacts on affected populations. The RA is intended to assist the MAJCOMs in deciding whether to pursue commercial off-the-shelf (COTS) technology solutions or research and development (R&D) options.

SUMMARY

The following technology needs addressed in this report are identified in the *FY96 United States Air Force Environment, Safety and Occupational Health Technology Needs Survey*:

Need ID	Title
1411	A Quantitative Dosage-Response Relationship for Predicting the Effects of Noise Is Required.
1410	A New Method Is Needed to Gather Defensible Aircraft Operational Data for Use in Determining Noise Levels for Aircraft Beddowns/Realignments; and the Air Installation Compatible-Use-Zone Program.
450	Need Analytical Methods to Determine Environmental Impacts of Sonic Boom from Launch Vehicles and Sonic/Supersonic Airplanes through Air Propagation and Underwater Propagation.
1413	Model Updates to the Assessment System for Aircraft Noise (ASAN) for Prediction of Noise Exposure from Military Aircraft Operations and the Resulting Impact to Humans, Animals, and Structures.
252	The AF, in Many Cases, Must Reduce Mission Rates Because of Community Noise Concerns.
411	Modeling is Needed of Environmental Impacts of the Noise and Sonic Boom Generated by Launching Large Space-Launch Vehicles.
1412	Methods Are Needed to Assess the Annoyance of Sporadic Exposure to Sonic Booms and the Combined Annoyance of Noise Exposure of Subsonic and Supersonic Operations.

The needs in this Noise technology group result from requirements of the National Environmental Policy Act (NEPA), the Noise Control Act (NCA), and other Federal, State, and local laws, as implemented through Air Force Policy Directive (AFPD) 32-70, *Environmental Quality*, and Air Force Instructions (AFI) 32-7061 and 32-7063, to perform noise analyses. NEPA requires the Air Force to give appropriate consideration to environmental concerns, including noise-related issues, prior to beginning any action that may affect significant changes in prior levels.

Potential solutions to these needs must meet the following criteria: (1) ensure that regulatory requirements are met without prolonged controversy; (2) be consistent with mission requirements; and (3) ensure that Air Force actions in response to environmental issues are based on legally defensible, state-of-the-art methods. Meeting these criteria, however, requires the deployment of technologies that fulfill not only scientific and technical requirements of reproducibility, accuracy, and validity but also social and legal tests of credibility and defensibility. Supporting a decision with state-of-the-art models, data, and analyses is insufficient to ensure that the information will be accepted by interested and affected parties as credible or will meet the legal requirements of defensibility. EPA and DOE experiences have both shown that establishing credibility involves developing a trust relationship with regulators and other interested and affected parties by involving them early in the development process so that they can understand and accept the outcomes. Legal defensibility requires extensive documentation to establish the integrity and ensure acceptance of data collection and analysis activities.

An extensive domestic and international search covering the major databases in which information on technologies addressing noise pollution was conducted. Additionally, a number of individuals involved in noise research, policy, and litigation were contacted. Findings were analyzed, and the following conclusions were drawn:

CONCLUSIONS

1. There are no COTS integrated sets of data and models available for the high priority needs in this group (Needs 1411, 1410, 450, 1413, and 252).

2. Noise-related regulatory areas are changing; hence, legal defensibility and credibility are critical to interested and affected parties accepting proposed solutions.

3. The Air Force, NASA, and the Federal Aviation Administration (FAA) are all involved in developing and/or using models and collecting data to develop better solutions to noise-related issues concerning aircraft operations.

4. Currently, it is Armstrong Laboratory's Noise Effects Branch (AL/OEBN) whose research program is most likely to provide the scientific and technical solutions to the needs in this technology group. The Air Force Armstrong Laboratory and NASA's Langley Research Center are the major organizations that have ongoing scientific and technical work at development stages 6.2 and 6.3, related to noise measurement and the effect of noise on the environment. However, several of the needs (1411, 450, 1413, and 252) are likely to be only partially met by the currently planned AL/OEBN program. Only Need 1410 appears to be fully met.

RECOMMENDED OPTIONS

1. The Air Force should continue to support the R&D option through programs at AL/OEBN, to find a solution to noise generated by aircraft and space launch vehicles. The supporting strategy is as follows:

    - Critically evaluate the scope of these programs in relation to the top priority needs and refocus or expand where necessary to ensure that success criteria are met.

    - Develop and implement strategies for producing technically peer-reviewed publications from all stages of the R&D process.

    - Implement highly visible, independent peer review processes that include technical representatives from interested and affected parties.

    - Ensure defensibility of the data through development and pilot testing of QA/QC processes, documentation, training programs, and SOPs for data acquisition and analysis, chain of custody tracking, and instrument use.

    - Develop training and certification processes which can be applied to all users of the technologies, particularly in support of litigation and regulatory procedures.

2. The AL/OEBN program for Mitigation of Environmental Noise includes several projects to develop communication tools that should be broadly deployed in advance of the widespread use of other research products.

3. The Air Force should fully evaluate the AL/OEBN program through cross-mapping the numerous milestones to the needs of the MAJCOMs and their contributions toward achieving the three success criteria. The evaluation would include a detailed examination of (1) the problems associated with noise analyses, (2) the time spans for required solutions, (3) the acceptance level of current data and models, (4) the factors that impair achievement of the user's three success criteria, and (5) potential modifications to the R&D process.

HUMAN SYSTEMS CENTER, ENVIRONMENTAL PLANNING DIRECTORATE TECHNOLOGY ASSESSMENT (Part 1) REQUIREMENTS ANALYSIS FOR

NOISE

1.0 BACKGROUND/PURPOSE

Background: The Human Systems Center, Environmental Planning Directorate (HSC/XRE) Technology Assessment (TA) analyzes the environmental, safety, and occupational health technology needs identified in the Air Force Technology Needs Surveys, identifies the technologies available to satisfy those needs, and presents both the most feasible methods for implementing the solutions and the risks associated with those solutions. Finding the most effective technology solution entails conducting two of the three parts of the TA: the Requirements Analysis (RA), and the Technology Evaluation (TE). The third part, the Systems Implementation Review (SIR), is conducted to evaluate the utility of the technology solution(s) actually implemented.

The RA provides preliminary information that can be used to select one of the following options: (1) to pursue potential commercial off-the-shelf (COTS) technologies, if appropriate and readily available; (2) to pursue research and development (R&D) activities that can lead to potential solutions for the technology needs; (3) to maintain the status quo and the ongoing course of action; or (4) to formulate policy or administrative changes. The TE, on the other hand, provides more detailed information to (1) implement COTS solutions for individual needs at site-specific locations; (2) select supporting R&D programs to develop products for satisfying the needs; or (3) support policy changes or administrative courses of action. The TE is conducted only if the cognizant Major Command decides to pursue an option outlined in the RA and desires assistance in doing so.

Purpose: This document is an RA, conducted to provide preliminary information on Noise technology needs to Air Force Major Commands (MAJCOMs) who may be affected by the implementation of solutions to those needs. The information presented, which is based on current technology, can be used to determine whether further investment in finding solution sets for noise-related environmental and safety technology needs may be warranted.

2.0 INTRODUCTION TO THE TECHNOLOGY GROUP

A Requirements Analysis (RA) addresses a family of related needs, called a technology group, so that the information searches and analyses conducted in the RA will be applied to those needs collectively. The technology group addressed in this RA pertains to needs that require the development of noise models to estimate the impact on humans and animal populations of noise generated by aircraft and space launch vehicles and transmitted through air and water.

2.1 Needs Commonality

The needs in this technology group stem from a common finding--that noise from aircraft is a significant source of annoyance[1,2,3] (and potentially a source of other adverse impacts) to people residing under flight paths or near air base facilities. In addition, the needs in this technology group are all affected by the following regulatory "drivers": (1) the National Environmental Policy Act (NEPA), (2) the Noise Control Act (NCA), (3) National Parks Overflight Act (NPOA), and (4) State and local laws, all of which are implemented through Air Force Policy Directive (AFPD) 32-70. These "drivers" require the Air Force to provide up-to-date assessments of the impact of its aircraft activities on affected populations and structures. Under NEPA and the Noise Control Act, the Air Force is required to conduct noise analyses for all activities that relate to the movement of aircraft. NPOA of 1987 requires the Air Force to conduct similar assessments for flight paths over National Forest System wilderness areas.

Under NEPA, as implemented through AFPD 32-70 and Air Force Instruction (AFI) 32-7061, which describes specific tasks and procedures for the Air Force's Environmental Impact Analysis Process (EIAP), a new environmental analysis must be conducted to support any decision that results in changes in the quality or the quantity of aircraft movement in and around an air facility. Decisions to make minor changes (e.g., replacing the old, noisier C-5s with the same number of new C-5s, which are fitted with quieter engines) can be supported with the NEPA categorical exclusion (CATEX) document. Making more dramatic changes (e.g., exchanging a fighter squadron for a transport squadron) entails following a detailed NEPA process that requires preparing an Environmental Assessment (EA) and, possibly, an Environmental Impact Statement (EIS) that would include a thorough noise analysis to evaluate potential impact changes. NEPA, implemented through EIAP, requires that the Air Force understand and disclose the impacts of noise exposures on human and animal populations populations and their environment in general. This understanding and disclosure must include information on impacts as diverse as noise nuisance to outdoor recreationists; glass shattering due to sonic booms; and noise-induced disturbances in mating habits, migratory patterns, and young-rearing behavior of animal populations and agriculturally important species. In addition, documents prepared under the EIAP must be based on the best scientific information and methods available and must support any decision that results in changes in the quality or

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[1] Galloway, W.J., "Assessment of Community Response to High Energy Impulsive Sounds," Report of *Working Group 84, Committee on Hearing, Bioacoustics and Biomechanics*, National Research council, National Academy of Sciences, Washington, DC, 1981.

[2] Fields, J.M., "An Updated Catalog of 318 Social Surveys of Residents' Reactions to Environmental Noise (1943-1989)," NASA TM-187553, 1991.

[3] Green, D.M., Fidell, S., "Variability in the Criterion for Reporting Annoyance in Community Noise Surveys," *Journal of the Acoustical Society of America*, Vol. 89, No. 1, 1991.

the quantity of aircraft movement in and around an air facility or operational changes within special use training airspace.

The Noise Control Act is implemented through AFPD 32-70 and Air Force Instruction (AFI) 32-7063, which provides development, implementation, and maintenance instructions for the Air Installation Compatible Use Zone (AICUZ) program. AFI 32-7063 requires all air facilities to perform a noise analysis every two years, focusing the analysis on documenting the change in noise contours around the facilities over the two-year period, to gather information that can be used for current and future land-use planning activities. Base commanders working with local communities use AICUZ data to determine where high, moderate, and low noise areas are located around their facility, so that noise-sensitive and non-noise-sensitive activities can be appropriately sited (e.g., a high noise area might be zoned for agricultural activities, while low noise areas might be reserved for hospital or school siting).

The circumstances that mandate noise analyses to satisfy NEPA, NCA, and NPOA requirements continually change, influenced by (1) improvements in state-of-the-art methods for assessing noise impacts; (2) an ever-increasing number of animal species of concern; (3) variability in community noise tolerance; and (4) modifications in MAJCOM requirements to realign aircraft and operations to meet flying mission needs. This means that any of the noise analyses can be challenged by interested parties whose interpretation of what constitutes the best scientific information and methods differs from that of the Air Force. To mitigate such challenges, the solutions to the needs in this technology group must fulfill the following requirements:

- Provide adequate data to credibly demonstrate compliance with regulatory requirements (NEPA, NCA, NPOA, and State and local ordinances) as well as adequately validate models used for planning and compliance assessment.

- Develop technical methods for defining and modeling the impacts of noise that are state-of-the-art, legally defensible, and accepted as credible by interested and affected parties.

- Increase credibility of the analyses conducted by demonstrating that the solutions proposed have been thoroughly researched and alternatives have been properly considered.

2.2 List of Needs

The technology group for noise-related needs is comprised of the following seven needs, listed in priority order. The point-of-contact (POC), Command, and telephone number are included in the description of each need. These needs are identified in the *FY96 United States Air Force Environment, Safety, and Occupational Health (ESOH) Technology Needs Survey*[4] (TNS) of December 1995, which is also the source of ID numbers and priorities.

Need ID: **1411 Top 1 %**

Title: **A Quantitative Dosage-Response Relationship for Predicting the Effects of Noise Is Required.**

Description: Because training operations may overfly lands used for outdoor recreation, the Air Force requires the ability to predict the effects of aircraft noise on the outdoor recreationist. Much of the special use airspace established and utilized by the Air Force is away from populated areas; as a result the outdoor recreationist is subjected to the aircraft overflight and noise exposure. Federal and State agencies which control the areas largely utilized by the outdoor recreationist have recently made the attempt to exert greater control over the airspace above the resources for which they are responsible, including that utilized by military aircraft. Today, no quantitative dosage-response relationship has been developed for predicting annoyance in these circumstances, and information on which such a relationship could be based is in short supply. Apart from a social survey of wilderness visitors sponsored by the Forest Service, and a study of park visitors' reactions to tour aircraft sponsored by the National Park Service, no useful quantitative information of any kind exists.

Considering the great value of reliable information about recreationists' reaction to aircraft overflights, it is worthwhile to the Air Force to undertake a study in an outdoor recreational setting.

Overall, new and refined methods of analysis are needed 1) to ensure environmental law requirements can be met without prolonged controversy, 2) to be consistent with and avoid impact to mission requirements, and 3) to ensure Air Force actions in response to environmental issues are based on legally defensible, state-of-the-art description and analysis methods.

POC: Ms. Brenda Cook, HQ ACC/CEVA, DSN 574-3056

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[4] *FY96 United States Air Force Environment, Safety, and Occupational Health Technology Needs Survey*, conducted by USAF ESOH Technical Planning Integrated Product Team, December 1995.

Need ID: 1410 Top 2 %

Title: **A New Method Is Needed to Gather Defensible Aircraft Operational Data for Use in Determining Noise Levels for Aircraft Beddowns/Realignments and the Air Installation Compatible-Use-Zone Program.**

Description: The Air Force in constantly realigning aircraft to meet the needs of the flying mission. A noise analysis is required for all actions involving the movement of aircraft during the National Environmental Policy Act (NEPA) process and every two years for the Air Installation Compatible Use Zone Program, in accordance with Noise Control Act and AFI 32-7063. The computer program used to calculate these noise levels (NOISEMAP) has been refined over the years and is highly defensible against outside challenges. Unfortunately, the methods used to gather the information required is extremely vulnerable to litigation.

The current data collection methods do not provide indisputable data. In fact, the accuracy of the data is totally dependent upon human interpretation and, therefore, extremely vulnerable to human error. The Air Force needs to develop a data acquisition system that will record and store actual aircraft flight information and convert it into data that can then be read directly into BASEOPS (the computerized input program for NOISEMAP). The data acquisition should also include ground maintenance activities which also contribute to the noise environment.

Additional benefits include actual historical information for air quality, determining the source of noise for complaints and lawsuits, assistance during accident investigations, and designing terminal instrument procedures.

POC: Ms. Linda Merritt, HQ ACC/CEV, (804) 764-3056 DSN 574-3056

Need ID: 450 Top 6 %

Title: **Need Analytical Methods to Determine Environmental Impacts of Sonic Boom from Launch Vehicles and Sonic/Supersonic Airplanes through Air Propagation and Underwater Propagation.**

Description: The AF creates numerous sonic boom impacts from both space launches and super/hypersonic airplanes on populated areas and native habit that are not well understood. The National Environmental Policy Act (NEPA) requires that the AF predict impacts of programs and report them to the public. Recent developments in sonic boom studies have made evident the need for amending the near-field analysis with nonlinear calculations and a need for an unambiguous matching procedure to improve waveform-prediction techniques. In addition, there is a renewed issue with "transition focus booms," particularly the "superboom," which occurs during a speed change through a threshold Mach number and gives rise to strong work-focusing effects; however, the intensity and extent of impact area cannot be established from existing methods. Another concern is the potential sonic boom impacts on pelagic and coastal environmental of which the Methodology for defining the impacts is not adequately developed. The AF is currently required by environmental agencies to monitor the impact of rocket sonic booms on animals downrange of launch sites at Vandenberg AFB.

POC: Mr. Pete Campell, HQ SMSC/CEV, (310) 363-0923 DSN 833-0923

Need ID: 1413 Top 6 %

Title: **Model Updates to the Assessment System for Aircraft Noise (ASAN) for Prediction of Noise Exposure from Military Aircraft Operations and the Resulting Impact to Humans, Animals, and Structures.**

Description: USAF requires the ability to conduct flight operations at its airfields, weapons ranges, and in designated airspace. This requirement is met by aircraft/mission realignments, acquiring and maintaining airspace, preventing or controlling encroachment of airfields and weapons ranges. Performance of this mission is dependent upon the ability to describe and assess, in a timely and defensible manner, the magnitude and impact of subsonic and supersonic noise, particularly

noise impacts associated with MTSs and MOAs. New and refined methods of analysis are needed 1) to ensure Environmental Law requirements can be met without prolonged controversy, 2) to be consistent with mission requirements, and 3) to ensure Air Force actions in response to environmental issues are based on legally defensible, state-of-the-art description and analysis methods.

The National Environmental Policy Act (NEPA) of 1969 requires federal agencies to analyze the potential environmental impacts of proposed actions and alternatives and to use those analyses in their decision-making process. The USAF Environmental Impact Analysis Process (EIAP) provides an understanding of the potential environmental consequences of proposed actions and alternatives.

A major part of the USAF-EIAP effort involves the prediction of aircraft noise effects around air bases in over 350 Military Operating Areas (MOAs), in restricted areas and along more than 600 Military Training Routes (MTRs), encompassing approximately one half million square miles of domestic airspace. The USAF must be able to predict aircraft noise levels in exposed areas, the effects of both subsonic aircraft noise and sonic booms on the populations, the dynamics of animal wildlife, health, and welfare of domestic animals, and damage to conventional and nonconventional structures.

Updates and additions to Version 1.0 of ASAN (scheduled for release FY95) will be required, including but not limited to Models for Predicting Effects of Aircraft Noise and Sonic Boom on Structure, Model to Assess Noise Impacts for Training Routes and Military Operating Areas, and Models for Predicting Effects of Aircraft Noise and Sonic Boom on Humans.

POC: Mr. Ron DiBenedetto, HQ AFCEE/ECP, DSN 240-2\3183
POC: Ms. Brenda Cook, HQ ACC/CEVA, DSN 574-3056

Need ID: **252 Top 10 %**
Title: **The AF, in Many Cases, Must Reduce Mission Rates Because of Community Noise Concerns.**
Description: The AF needs to reduce the impact of noise on communities from flying missions. Local ordinances restrict the level of noise that is allowed to impact local communities. These restrictions directly impact the number of missions that we are allowed to conduct near these communities. A means to mitigate or reduce the noise levels impacting local communities, while allowing the Air Force to conduct the number of missions necessary for readiness operations is required.
POC: Lt. Col. Al Badeau, 75 MDG/SGPB, (801) 777-1181 DSN 777-1181

Need ID: **411 Top 67 %**
Title: **Modeling is Needed of Environmental Impacts of the Noise and Sonic Boom Generated by Launching Large Space-Launch Vehicles.**
Description: Space and Missile Systems Center launch vehicles produce high levels of noise and sonic boom energy which are known to be harmful to humans (requiring evacuation) and suspected of being harmful to animal species in the vicinity. At Vandenberg AFB and Cape Canaveral Air Station, endangered/threatened species such as the least tern, snowy plover, and West Indian manatee are subjected to this environment during launches. Damage to hearing from launch vehicle noise and sonic boom is suspected to cause reproductive and feeding failure, resulting in further decline of protected species. To properly protect them and meet the requirements of the Endangered Species Act, a better understanding of the effects is needed.
POC: Capt. Brian Laine, SMSC/CLNE, (310) 363-1095 DSN 833-1095

Need ID: 1412 Top 67 %

Title: **Methods Are Needed to Assess the Annoyance of Sporadic Exposure to Sonic Booms and the Combined Annoyance of Noise Exposure of Subsonic and Supersonic Operations.**

Description: USAF requires the ability to conduct supersonic flight operations in approved airspace. Past combat experience has demonstrated that the effectiveness and survival of aircrews exposed to sophisticated aircraft and advanced antiaircraft weapons systems are directly affected by the type, quality, and amount of training they receive. As a result of the AF training mission, there is public concern over the impacts of noise and sonic booms. Performance of the AF mission is dependent upon the ability to describe and assess, in a timely and defensible manner, the magnitude and impact of subsonic and supersonic noise. New and refined methods of analysis are needed 1) to ensure Environmental Law requirements can be met without prolonged controversy, 2) to be consistent with mission requirements, and 3) to ensure Air Force actions in response to environmental issues are based on legally defensible, state-of-the-art description and analysis methods.

The dosage-response relationship on which the Air Force currently relies for predicting the annoyance of exposure to sonic booms was produced by the 1981 CHABA Working Group 84 on the basis of modest amounts of information about repetitive and expected noise exposures in residential communities. The applicability of this relationship to many settings of practical interest to the Air Force has never been demonstrated. Both physical and psychoacoustic issues must be resolved to increase confidence in the Air Force's method for assessing impacts of sporadic sonic booms over largely dispersed populations.

Additionally, the Air Force predicts the annoyance due to noise exposure from subsonic operations and that due to supersonic operations separately, by means of two different dosage-response relationships. An accurate combined annoyance prediction from both types of operations is not currently available. ACC must be able to predict community response in settings subject to both subsonic and supersonic flight operations.

POC: Ms. Brenda Cook, HQ ACC/CEVA, DSN 574-3056

Subsequent discussion focuses on the five top priority needs, Needs 1411, 1410, 450, 1413, and 252. Needs 411 and 1412 are low-priority (67%) needs and have not been specifically addressed in this report. However, these needs have requirements in common with the top priority needs and may also have solutions in common; however, they are not discussed in detail in this RA.

2.3 Clarifying Needs and Establishing Subgroups

To ensure the utility of this document for assisting the MAJCOMs in making defensible decisions, each need was discussed with the respective point-of-contact (POC) and in the context of current related technology. The following criteria for satisfying the needs were established:

1. Ensure that regulatory requirements are met without prolonged controversy.

2. Be consistent with mission requirements.

3. Ensure that Air Force actions in response to environmental issues are based on legally defensible, state-of-the-art methods.

In addition, the needs were deemed similar enough to be considered as a single group. The descriptions of four of the top five priority needs indicate an imperative for two outcomes: (1) a better understanding of the environmental impacts of noise on humans, animals, and/or structures and (2) a better ability to model and predict, accurately and defensibly, the potential changes in noise impacts from changes in aircraft movement. The description of the fifth top priority need, Need 252, though not explicitly stating so, indicates that achieving such outcomes will be necessary if new approaches to mitigating or reducing the noise levels that affect local communities are to be developed. This RA therefore addresses Need 252 in the context of modeling but does not address technical approaches to reducing the noise levels described. Those approaches will need to be addressed in a separate document. Based on the comments of the Need's Point-of-Contact, Need 1410 was modified to include noise modelling of ground maintainenace activities. This aspect will be addressed by Armstrong Laboratory's noise programs.

The top priority needs have in common a strong rationale for finding effective technology solutions: the MAJCOMs want to achieve their mission requirements involving aircraft operations and space launches. Concerns on the part of regulators, communities, and other interested and affected parties, particularly when expressed as legal actions under the provisions of NEPA and other laws, can result in delays in meeting mission requirements and/or increases in costs, which may also impede achieving mission requirements. Because the needs addressed in this technology group are driven by the same requirements, they are treated in aggregate in this Requirements Analysis.

3.0 ANALYSIS AND RECOMMENDED OPTIONS FOR THE TECHNOLOGY GROUP

Research on information pertaining to COTS and R&D solutions for the Noise technology group focused initially on the Air Force and then expanded into the wider international arena. The major science/technology, environmental, chemical, and medical databases were searched to gather pertinent technological data from a time frame spanning the early 1970s to the present. Twelve databases were examined:

1. Defense Technical Information Center (DTIC)
2. Aerospace Database
3. SciSearch
4. Conference Papers Index
5. CA Search
6. Transportation Research Information Service
7. Enviroline
8. Environmental Bibliography
9. Pollution Abstracts
10. Energy Science and Technology
11. Federal Research In Progress
12. Toxline

Other databases identified as appropriate to the technology area were searched when deemed necessary to ensure a comprehensive search. The Internet was also searched, using such search engines as Metacrawler, Alta Vista, and Lycos. The following discussion and analysis presents pertinent information gained from these searches.

Several issues are under discussion within the scientific community: (1) the best metrics for a particular impact[5]; (2) how best to capture the differences in response to impulsive and non-impulsive noise[6]; (3) the importance of self-noise generated by the listener[7]; and (4) the definition of ambient quiet. These issues continue to generate on-going research projects with regard to the appropriate dose-response curves and noise metrics used to estimate the likelihood that different populations (e.g., adults, children, raptors, structures) under differing

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[5] Cook, B.W., 1993, "Analysis Methodologies for Noise and Air Quality," Proceedings of *1993 Air Combat Command Environmental Quality Symposium*, pp. 74-96.

[6] Fidell, S., Pearsons, K., 1994, "Deriving a Dosage-Response Relationship for Community Response to High-Energy Impulsive Noise," Proceedings of *High Speed Research: 1994 Sonic Boom Workshop*, NASA Conference Publication 3279, Oct., David McCurdy editor.

[7] Harrison, R., Hartman, L., Makel, W., 1990, "Annoyance from Aircraft overflights in Wilderness," Noise-Con 90, Proceedings *10th National Conference on Noise Control Engineering*, Austin, TX, Oct. 15-17, pp. 327-332.

exposure regimens (e.g., sonic vs. subsonic, continuous vs. intermittent exposures) will experience different end points (e.g., annoyance, hearing loss, and impaired reproductive function).

Numerous national and international efforts to measure, understand, and predict the impacts of military aircraft noise are on-going. The results of research programs in Sweden[8], Germany[9], Norway[10], and the Netherlands[11] are representative of the kind of information member nations of the European Community are developing with regard to assessing and managing noise from military aircraft operations. However, to date, these research and development efforts have not resulted in commercially available products. Our review indicates that for the Air Force's specific requirements, research and development ongoing in the United States is the most advanced. Thus, the following discussion focuses on work conducted within the United States and, specifically, within the U.S. Department of Defense.

Satisfying the requirements of the needs in this technology group necessitates that noise analyses be conducted under the EIAP and the AICUZ program, which use different models and data. The EIAP's focus is on identifying and evaluating potential impacts of military aircraft training/operations around Air Force installations and within/beneath special use airspace ,(e.g., military training routes (MTR) and military operating areas (MOA)). In contrast, the AICUZ program is designed to provide the air facilities and nearby communities information about noise level contours for incorporation in land-use planning decisions (e.g., high noise areas for cropland and low noise areas for special facilities, such as hospitals or schools). Over time, conducting noise analyses for either the EIAP or AICUZ program have become very complex. For example, developing noise contours required by the AICUZ program involves consideration of the appropriate noise metrics; accurate, consistent, and reliable methods for capturing operational data; and an in-depth knowledge of the physics of acoustics and the ways in which changes in weather parameters can modify sound quality and transfer through the environment.

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[8] Lilja, G. and Larsson, L.G., 1994, "Aviation and the Environment: Needs for Research in Sweden," KFBs DNR: 92-328-22, ISBN 91-88370-71-2.

[9] Gummlich, H.J. and Marohn, H.D., 1995, "Aircraft Noise Metrics and Zones: International Comparisons and Conversion," Proceedings *CEAS/AIAA Joint Aeroacoustics Conference*, 2:911-917.

[10] Gjestland, T., Liasjo, K.H., and Granoien, I.L.N., 1995, "Community Response to Noise from Short-Term Military Aircraft Exercise," *J. Sound and Vibration*, 182:221-228.

[11] de Jong, R.G., 1990, "Community Response to Noise: A Review of Recent Developments," *Environ. Int'l*, 16:515-522.

The appropriate noise metric may be highly variable, depending on the receptor. The human ear, for example, does not perceive all sound frequencies equally. It is less sensitive to low frequencies than to mid-range frequencies. Thus, derivation of the appropriate dose metric requires application of a frequency weighting system which, similar to the action spectrum used in assessing the impacts of ultraviolet radiation on humans, gives more weight to the effective (e.g., higher impact) frequencies. The effective dose metric is also related to the outcome of interest. For example, the appropriate dose metric for human annoyance appears best captured by the A-weighted sound level which assesses the instantaneous level of effective sound, and varies with the changing level of the sound environment. Different metrics may be more appropriate for the reaction of other species to noise, however, or even for different human impacts.

According to the EPA[12], the best metrics to describe the effects of environmental noise are:

1. The Long-Term Equivalent A-Weighted Sound Level (L_{eq})

2. The Day-Night Average Sound Level (DNL), which may be symbolized as L_{dn}.

A-weighting de-emphasizes the low- and high-frequency range of the sound spectrum in order to provide a good approximation of the response of the average human ear and correlates well with a person's judgment of the relative loudness of a noise event. L_{eq} is the average of the A-weighted sound levels over a period of time. The absence of a standardized averaging period makes it difficult to use this metric to compare data for events of different durations. The DNL is the L_{eq} measured over a period of 24 hrs, with a 10dB penalty applied to nighttime (10 p.m. to 7 a.m.) sound levels to account for increased annoyance by sound during night hours. The annual average DNL provide the basis for the Air Force's AICUZ program. Supplemental metrics used to characterize specific effects on a case-by-case basis include, L_{eq} for varying representative time periods, Sound Exposure Levels (SEL), Third Octave Band Sound Pressure Level (SPL), L_{max} (A-weighted maximum sound level), and TA (time above- expressed in minutes for which aircraft-related noise exceeds specified A-weighted sound levels).

Operational data quality is also critical for noise analyses. The Air Force flight facilities routinely record information on the frequency, duration, and routes of flight activities and on the number and types of aircraft flown. However, detailed information as to flight speed and altitude changes over time, which are needed to assess the noise levels accurately, has generally been gathered on a more ad hoc basis[13]. Surveys of pilots and air traffic control

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[12] EPA- 550/9-47-004, Information on levels of environmental noise requisite to protect health and welfare with an adequate margin of safety, (1974), also refered to as the "Levels Document"

[13] Contact Report of 4/22/96: Janice Longstreth, WPI, to Bob Lee, AL/OEBN (513) 255-3664.

tower occupants, rather than automated data collection through instrumentation, have frequently been used to develop these assessments. The noise contour estimates have, as a consequence, not been particularly reliable and may result in inappropriate predictions.

The noise analyses required under the AICUZ program are based on a pair of integrated models. BASEOPS is the operational data input model, and NOISEMAP is the noise contour calculation model. NOISEMAP can be integrated with one or more dose-response models to estimate potential risks. However, dose-response models are generally specific to the outcome and animal of concern, so that each time a new outcome or animal of concern is identified, a new dose-response model must be developed.

As used for the AICUZ program, NOISEMAP considers all aircraft operations at an installation and uses the DNL metric to produce noise level estimates with 5 decibel (dB) contour gradations. These contours are then used to develop predicted noise exposure levels for various installation locations under the operational change scenarios of interest. These predicted levels are then compared to the noise baseline for the facility, which is based on similar contours derived from noise levels associated with current operations. Another program, ROUTEMAP, is used to obtain a total noise level estimate across a Military Training Route (MTR) by summing the individual noise levels for MTR segments.

The Air Force has recently completed the development of a suite of computer programs for evaluating noise impacts under military airspaces. The suite consists of; MR_NMAP (MOA Range NOISEMAP), a general purpose program that calculates noise contours under MOAs and MTRs; MR_OPS , a companion interface program that facilitates defining the airspace, specifying aircraft types and operations and controlling the computational features of MR_NMAP; and NMPLOT, the Air Force's standard noise contour plotting program.

The U.S. Department of Defense (DOD) has an extensive ongoing program related to noise modeling. However, that program does not provide the Air Force with the full set of noise models currently needed, nor does it ensure the full acceptance of the Air Force program by the affected parties. The reason is that conducting a noise analysis is often a complex process involving the measurement, interpretation, and estimation of a large number of parameters for which there is considerable uncertainty and limited consensus on methods. The following subsections detail the options and rationale for the recommendations made concerning the noise technology group.

3.1 Commercial Off-the-Shelf (COTS) Technologies

There are no COTS available for the top priority needs (Needs 1411, 1410, 450, 1413, and 252) in this technology group. The state-of-the-art in these areas is changing, and no evidence was found of a commercially-available, integrated set of models directly linked to data collection instrumentation that addresses the principal requirements of the needs. Most of the solutions to these needs require improvements to existing software and hardware currently being used by MAJCOMs to meet the regulatory requirements of NEPA and other statutes.

Indeed, the results of this RA indicate that in addition to the Air Force's products being representative of state-of-the-art technology, the Air Force requirement to perform increasingly sophisticated noise analyses is the major impetus for improvements in those state-of-the-art technologies.

Need 1410 also identifies a requirement for better operational data collection methods. These methods should, preferably, not be dependent on human interpretation and should have the capacity to collect and directly convert the data to a format compatible with the programs used for the noise analyses required by the EIAP or AICUZ program. No evidence that a technology that meets the requirement in Need 1410 is currently available commercially was found.

3.2 Research and Development Activities

Research and development efforts in the U.S. that are similar to the international programs mentioned earlier (see page 9, section 3.0) are principally addressed by the Air Force[14] and the National Aeronautics and Space Agency[15] (NASA). These organizations have research activities in progress that should satisfy the requirements associated with the top five priority needs in this technology group (Needs 1411, 1410, 450, 1413, and 252) and may, in addition, provide complete or partial solutions to Needs 411 and 1412.

3.2.1 Key Organizations

The Noise Effects Branch of Armstrong Labs (AL/OEBN) is the U.S. Air Force's lead laboratory for addressing noise issues related to data collection, analytic methods, model development and validation, and noise mitigation. Contractors important to this area include BBN Systems and Technologies and Wyle Laboratories. In addition, several NASA facilities, particularly the Langley Research Center, are heavily involved in noise research issues, particularly those related to sonic booms. Addresses and key contacts for each of these organizations are as follows:

1. Armstrong Labs
   AL/OEBN
   Dr. Robert Lee
   (513) 255-3605

2. NASA, Langley Research Center
   Hampton, Va
   Mr. Kevin Shepherd
   (804) 864-3583

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[14] Cook, B.W., 1993, "Analysis Methodologies for Noise and Air Quality," Proceedings *1993 ACC Environmental Quality Symposium*, pp.74-91.

[15] Shepherd, K.P., Brown, S.A., Leatherwood, J.D., McCurdy, D.A., and Sullivan, B.M., 1995, "Human Response to Sonic Booms - Recent NASA Research," *Internoise 95*, pp. 871-874.

3. BBN Systems and Technologies
Canoga Park, CA
Dr. Sanford Fidell
(818) 347-8360

4. Wyle Laboratories
Arlington, VA
Dr. Kenneth Plotkin
(703) 415-4550

3.2.2 Stage of Development

The Air Force, NASA and the Federal Aviation Administration (FAA) are all involved in developing and/or using models and collecting data to develop better solutions to the problems identified in this technology group (although the FAA principally focuses on issues related to commercial aircraft). The research has been on-going for many decades. However, with the possible exception of the work conducted by AL/OEBN, no evidence was found of an integrated, systems-based approach for solving issues posed by noise exposures connected with peacetime military missions. Such a systems approach would provide a general framework for assessing noise impacts at any airfield and incorporate and integrate the best features of all the available models and databases.

The AL/OEBN has four principal programs that directly or indirectly address the needs in this technology group. Given below are the titles, numerical designations, and development stages (DS) of these programs and a table that indicates AL/OEBN's assessment[16] of how completely these programs address the priority needs of this technical group.

1. Environmental Noise Modeling and Measurements, S-96-OEBN-1, DS:6.2
2. Assessment System for Aircraft Noise (ASAN), OEBN-2, DS:6.3
3. Impacts of Environmental Noise on Humans, Animals and Structures, OEBN-3, DS:6.2
4. Mitigation of Environmental Noise, OEBN-4, DS:6.3

[16] AL/OEBN response 1 March 1996 to HSC/XRE Ltr., 19 Jan. 1996. Subject: Laboratory Input for ESOH Strategic Plan.

AL/OEBN Assessment of Program's Ability to Satisfy Need

	OEBN-1	OEBN-2	OEBN-3	OEBN-4
Need 1411			++	+/-
Need 1410	++			
Need 450	++			
Need 1413		++	++	
Need 252	++	+	++	++

+++ = fully meets need; ++ = partial solution;
+ = will likely lead to a solution; +/- = may indirectly meet need

The information presented indicates that the AL/OEBN research program will partially meet Needs 1410, 1411 and 450. Needs 1413 and 252 may be fully met if the partial solutions derived from the multiple programs that address them comprise a complete solution. The AL/OEBN program does not fully address all of the needs in this technology group, however. A more thorough exploration of the AL/OEBN program would be required to determine the specific gaps exist that exist and their importance in addressing the top priority needs adequately.

One of the issues that still needs to be addressed is the appropriate metric for modeling sound levels of flights resulting in sonic booms. The DNL metric used in NOISEMAP was found to be inappropriate. The Air Force subsequently developed PCBOOM3, a general purpose, single-event sonic boom prediction model that supports building input cases, running boom calculations, displaying contours and signatures, and managing associated data. Together with prior versions of similar programs such as BOOMAP2, MOAOPS, TACTS/ACMI, and a library of aircraft sorties from Military Operating Areas, PCBOOM3 provides a method that predicts and characterizes sonic booms with reasonable accuracy. PCBOOM3 is being upgraded by AL/OEBN to include launch vehicle boom capability, high altitudes associated with launch vehicles, inclusion of rocket plume effects, and the capability of importing trajectory/maneuver data from external sources. This effort will contribute to solutions for technology needs in this group.

Appropriate dose-response relationships for the chronic impacts of high intensity exposures need to be developed, however. Recent NASA Langley studies conducted on the impacts of long-term exposure of human communities to sonic booms have found that annoyance response to sonic booms appears to be greater than would have been predicted from the results of a well-designed matched aircraft noise survey and several widely-accepted summaries of dose-response relationships.

This RA provides preliminary information that can lead to potential solutions. The preliminary information obtained about the AL/OEBN programs indicates that the program is technically sound, but although the AL/OEBN program for Mitigation of Environmental Noise includes several projects to develop communication tools, there is not strong evidence that the program adequately addresses the critical requirements for ensuring legal defensibility and stakeholder acceptance. A basis for this conclusion is the U.S. Department of Energy's (DOE) experience in developing community acceptance of its actions, the intentions of which were to remediate its sites around the United States and to transport nuclear material across the country. Over a lengthy period, DOE determined that the following factors are important to legal defensibility and stakeholder acceptance:

- Development and implementation of technical peer review of documents published from all stages of the R&D program.

- Development, testing, and validation of QA/QC processes to ensure defensibility of data.

- Development of training and certification processes for all users of the technology.

- Development of communication tools for outreach.

These same factors appear to require greater Air Force support for effective inclusion in the AL/OEBN program. A follow-on TE would result in closer collaboration with the laboratory and the Air Force users and would more closely assess these factors in the program.

Two noise-related projects are funded under the Strategic Environmental Research and Development Program (SERDP): an Air Force project included in the OBEN-3 program and a related Army project. The two SERDP-funded projects are as follows:

1. The Effects of Aircraft Overflights on Birds of Prey
   Major Robert C. Kull, Jr.
   AL/OEBN
   (513) 255-3675

2. Controlling, Assessing, Managing, and Monitoring the Noise Impact from Weapons, Helicopters, and Aircraft on Training and Readiness.
   Dr. Paul Schomer
   U.S. Army CERL
   (217) 352-7229

The Armstrong Labs project started in 1994 and is expected to be completed in 1997. The major objective of this project addresses concerns raised by the U.S. Fish and Wildlife Service. The project will develop an additional dose-response model for integration in ASAN. The CERL project addresses DOD-wide noise problems, and covers the noise effects of helicopters, fixed-wing aircraft, artillery, night-time training, and the meteorological effects on noise propagation.

3.2.3 Order of Magnitude Cost Estimates

Based on AL/OEBN submissions to the USAF Environment, Safety, and Occupational Health strategic plan, rough order of magnitude costs for the current programs are baselined at $860K (FY96) and are growing to $1.1M by FY03[17]. Additional funding on an annual basis may be added from competitively-awarded funds (SERDP, Small Business Innovative Research, etc.). Currently (through FY96), AL/OEBN operates with a total budget of about $4 million. Significant portions of AL/OEBN's proposed program have been unfunded or under-funded, with the shortfall across the four programs between FY96 and FY03 estimated at $13 million.

3.2.4 Qualitative Risk Assessment

The risks associated with the R&D option and existing program at AL/OEBN are as follows:

- The total set of requirements under this technology group may not be met as indicated in the previous table, "AL/OEBN Assessment of Program's Ability to Satisfy Need." Only Need 1410 is currently judged, on the basis of the information available, as being fully-satisfied under the scope of the programs.

- Research products may not be available when needed. These programs are only in stages 6.2 to 6.3; therefore, several years may be required to develop the data, models, and tools to the degree of complexity needed to affect immediate high priority needs.

- Noise analyses developed by Air Force research products may be technically adequate but not acceptable to interested and affected parties outside the Air Force because the efforts are not viewed as credible. If products are not acceptable, then the Air Force is open to further delays, litigation, or prolonged controversy.

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[17] AL/OEBN response 1 March 1996 to HSC/XRE Ltr., 19 Jan. 1996. Subject: Laboratory Input for ESOH Strategic Plan.

- Research focused only on improved data collection and model development may be viewed by interested and affected parties as not directly addressing the real problem of reducing noise and its impacts. Public outreach and education programs must adequately demonstrate that engine and airframe designs are already in an advanced stage of development and that further efforts in those areas are unlikely to produce a significant decreases in noise levels.

In order to ensure that the above risks are minimized, the following actions should be considered:

- Reviewing the AL/OEBN program to determine what special gaps exist in program scope and their implications in adequately addressing top priority needs.

- Ensuring that documentation of research and development is comprehensive and made available to regulators and interested and affected parties.

- Including regulators and other interested and affected parties in the development process.

- Verifying that research products are state-of-the-art, thereby enhancing credibility and value.

- Ensuring that data and conclusions meet appropriate tests for legal defensibility, [e.g., chain of custody, adherence to Good Laboratory Practices (GLP) or its equivalent, accreditation of laboratories, etc.].

- Ensuring acceptance by all appropriate regulators and interested parties.

- Including independent external technical peer reviews and evaluations to facilitate certification that may eventually be required of any model or process used in regulatory or legal proceedings.

- Ensuring model validation that compares model estimates against real-time data.

- Ensuring bench-marking with checks that the model under development produces similar results to other, previously validated models used elsewhere.

- Providing for implementation by ensuring that there are adequate models, data acquisition and analysis processes, and hardware and associated software [with sufficiently detailed and understandable documentation/standard operating procedures (SOPs), training programs, and QA/QC processes to ensure correct use by individuals other than their creators], and that the resulting products are credible and defensible.

- Including representatives from local colleges and universities, outside experts in support of the local community, and appropriate regulators and professionals from the public and occupational health communities, which could result in faster acceptance of regulatory documents and fewer litigations in those geographic locations/MAJCOMs where disruptions may have previously occurred.

3.3 Other Considerations

As discussed previously, there are several models under development that are being refined with improved data for specific situations. Models in and of themselves are non-goal oriented, in that they do not reduce noise levels in any way but can only aide in the understanding of impacts. Models can consist of computer programs, databases, or, simply, relationships that explain cause and effect relationships. The added advancement from recent modeling efforts tends to be only marginal because the models are already well-developed. Similarly, the advancements in aircraft technologies relating to lightweight, low-sound profile air frames and quiet engines have been considerable, such that further significant improvements to reduce noise are viewed as marginal. A large amount of effort is required to improve either the models or aircraft technologies beyond current standards. No significant breakthroughs are expected. For this reason, the major thrust is to work with the affected communities to improve their understanding and confidence in the Air Force's abilities to monitor and determine impacts of the noise generated on the environment and communities. The ability to conduct these assessments is important.

Most of the needs in this technology group have been described in a fashion that makes it clear that users are expecting technical solutions that are "legally defensible, state-of-the-art"[18]. Unfortunately, with regard to environmental decisions, a variety of Federal agencies have found that technical improvements may have little or no effect on the acceptance of information by interested and affected parties. In many such instances, the past practices of a particular Agency or Department has resulted in a lack of credibility to the point that none of the information generated by the government or its contractors is believed. Subsequent disputes may lead to litigation. Legally defensible technical input may allow the government to win these disputes, but only after a considerable investment of time. The MAJCOM can ill afford this situation, given its need to fulfill a mission. Lack of credibility is likely to make it difficult to fulfill another requirement of these needs: "Ensure environmental law [regulatory] requirements can be met without prolonged controversy[17]". Needs 1411 and 1413 cannot be achieved strictly by improvements in the technical aspects of these analyses.

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[18] *FY96 United States Air Force Environment, Safety, and Occupational Health Technology Needs Survey*, (Needs 1411, 1412, and 1413), conducted by USAF ESOH Technical Planning Integrated Product Team, December 1995.

If there is a lack of credibility in the community of interested and affected parties associated with noise analyses, then it is unlikely that any technical improvements achieved without the full involvement of regulators and other interested and affected parties (and/or their technical representatives) will lead to complete needs resolution. To develop complete solutions, the Air Force must work with interested and affected parties to identify those characteristics that confer credibility on an R&D program and must use this information to direct its noise R&D program. The effort would need to be a joint one between the Air Force and its interested and affected parties and would likely require either the use of local implementation mechanisms that are viewed as quasi-independent of the Air Force (e.g., cooperative agreements with local universities) or a research program managed by another agency such as the National Science Foundation or National Institute of Health.

Finally, despite the fact that the Air Force routinely has about $10 million[19] in claims pending relating to aircraft overflight issues, these claims have never been found to be related to non-compliance situations. Nevertheless, the claims typically result in disbursements of about $3.3 million each year. Development of improved credibility and improved relations with the interested and affected parties could potentially lessen the number of claims and the amounts of the disbursements.

3.4 Recommended Options

Recommended Option 1: That the Air Force continue to support the R&D option through programs at AL/OEBN, to find a solution to noise generated by aircraft and space launch vehicles.

The supporting strategy is as follows:

1. Continue with the on-going noise-related R&D programs through AL/OEBN.

2. Critically evaluate the scope of these programs in relation to the top priority needs, and refocus or expand where necessary to ensure that success criteria are met.

3. Develop and implement strategies for producing peer-reviewed publications from all stages of the R&D process.

4. Implement highly-visible, independent peer review processes that include technical representatives from interested and affected parties, that cover all components of the process used to generate documents addressing noise measurement, and that affect assessments that can be used in litigation or regulatory proceedings.

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[19] Communication with Mr. Ronald Forcier, Chief of Real Property, Air Force Legal Service Agency, Arlington, VA, (703) 696-9166.

5. Ensure defensibility of the data through development and pilot testing of QA/QC processes, documentation, training programs, and SOPs for data acquisition and analysis, chain of custody tracking, and instrument use.

6. Develop training and certification processes that can be applied to all users of the technologies, particularly in support of litigation and regulatory procedures.

Recommended Option 1 is based on the conclusions that:

- There are no applicable COTS integrated set of models available for the high priority needs in this group.

- Regulatory areas related to noise are changing; therefore, credibility and legal defensibility are critical to the acceptance of proposed solutions by interested and affected parties.

- Credibility and legal defensibility are critical to the acceptance of proposed solutions by interested and affected parties.

- There is only marginal gain to be made in the reduction of noise from aircraft, due to the advanced state of aircraft design.

The following recommendations further amplify parts of this strategy.

Recommended Option 2: **That communication tools under development be used for outreach and that the testing of these tools for this activity be included either in the 6.3 or early 6.4 stages of the R&D process.**

The AL/OEBN program for Mitigation of Environmental Noise includes several projects to develop communication tools that should be broadly deployed in advance of the widespread use of the other research products.

Recommended Option 2 is based on the conclusions that:

- The Air Force, NASA and the Federal Aviation Administration (FAA) are all involved in developing and/or using models and collecting data to develop better solutions to noise-related issues concerning aircraft operations (though the FAA principally focuses on issues related to commercial aircraft), and communities should be made aware of this work.

- Currently, it is Armstrong Laboratory's Noise Effects Branch (AL/OEBN) whose research program is the most likely to provide the scientific and technical solutions to the needs in this technology group.

- The Air Force Armstrong Laboratory and NASA's Langley Research Center are the major organizations that have ongoing scientific and technical work at development stages 6.2 and 6.3, related to noise measurement and the effect of noise on the environment.

Recommended Option 3: **That an evaluation be performed that more fully explores how the numerous milestones contained in the AL/OEBN program map to the needs of the MAJCOM and contribute to the successful achievement of the three criteria for success.**

The evaluation would include a detailed examination of (1) the problems associated with noise analyses; (2) the time spans for required solutions; (3) the acceptance level of current data and models; (4) the factors that impair achievement of the users' three success criteria; and (5) potential modifications to the R&D process.

Recommended Option 3 is based on the conclusions that:

- Several of the needs (1411, 450, 1413, and 252) are likely to be only partially met by the currently planned AL/OEBN program. Only Need 1410 appears to be fully met.

- Funding is a mixture of both Air Force and non-Air Force funds.

HSC/XRE follow-on assistance:

If the Major Command desires assistance from HSC/XRE for more detailed analysis, HSC/XRE can perform Part 2 of a Technology Assessment, which is called a Technology Evaluation (TE). The TE will determine need- and site-specific solution sets to the defined needs. A clear definition of the objective for and desired assistance from a TE will be developed in close coordination with each MAJCOM involved or with other designated points of contact. It is estimated this TE could be accomplished within the range of four to ten weeks, once defined and funded.

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